BEFORE THE COLORADO WATER QUALITY CONTROL COMMISSION
Department of Public Health and Environment, State of Colorado

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PREHEARING TESTIMONY OF STEVEN P. CANTON, GEI CONSULTANTS, INC. ON BEHALF OF COLORADO MINING ASSOCIATION

IN THE MATTER OF THE ADOPTION OF REVISIONS TO THE BASIC STANDARDS AND METHODOLOGIES FOR SURFACE WATER, REGULATION #31 (5 CCR 1002-31)

INTRODUCTION

On behalf of the Colorado Mining Association (CMA), GEI Consultants, Inc. (GEI) has evaluated the acute and chronic aluminum and zinc water quality standards for the protection of aquatic life. Based on GEI's evaluation, CMA is proposing technical updates to Colorado's acute and chronic aluminum and zinc water quality standards for the protection of aquatic life. This testimony provides 1) a general description of the EPA ambient water quality standards development procedure, 2) summary discussions of CMA's proposed standards updates, and 3) comparisons of the current and proposed standards. More detailed information is provided in the two technical documents accompanying this testimony.

STANDARDS DEVELOPMENT METHODOLOGY

There are standard procedures for developing ambient water quality standards, based on the EPA criteria derivation and recalculation guidance (Stephan et al. 1985, EPA 1994). The first step is to gather all available data on the toxicity of a chemical to various forms of aquatic life. These studies are then subjected to detailed technical review to determine if the data are valid. Stephan et al. (1985) provides guidelines for determining whether data from a particular study are acceptable for use. Acceptable data are then compiled to develop acute and chronic toxicity databases containing data for a variety of species. In the case of updating older standards documents, as is the case for the metals in this proposal, existing toxicity databases are reviewed for accuracy and literature searches are performed to ensure the databases are complete and include the most up-to-date science.

In order to perform acute standards derivation calculations, it is necessary to have acute data for at least eight different families, as noted below (Stephan et al. 1985). This is generally known as the "eight-family rule", and includes:

1) Salmonidae (such as trout and salmon)
2) 2nd bony fish family (Class Osteichthyes, such as bass, minnows, catfish)
3) 3rd chordate (another fish or amphibian)

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CMA EXHIBIT 1

4) Planktonic crustacean (such as daphnids)
5) Benthic crustacean (such as crayfish)
6) Insect (such as mayflies or stoneflies)
7) Non-arthropod invertebrate family (such as snails or clams)
8) Family in another insect order or phylum not otherwise represented (such as flatworms or segmented worms)

This minimum data requirement (MDR) ensures that any water quality criterion calculated will be protective of a wide variety of species. The same MDR applies when deriving chronic standards; however, because the availability of chronic data is often more limited than acute, an alternative method is available that allows derivation of chronic standards other than by direct calculation. In this case, if acute and chronic data for at least three families (fish, invertebrate, and a sensitive species) are available, an acute-to-chronic ratio (ACR) can be calculated. Using the ACR, chronic standards values can be calculated from the acute standards calculations.

EPA guidance then uses these data, ranked from most sensitive to least sensitive, to derive water quality standards intended to be protective of 95% of the species expected to be present in water bodies. This 95% protection can be modified by the need to protect recreationally, commercially, or other important species, in which case the calculated values are adjusted to be protective of those special groups. Examples of standards derivation methods and such modifications are included in the discussions of the proposed standards updates below and in the accompanying technical documents.

PROPOSED UPDATED AQUATIC LIFE WATER QUALITY STANDARDS

A summary of CMA's proposed updated aluminum and zinc standards is presented below (Table 1). Because they represent the most up-to-date science, these updated standards are a considerable improvement over current Colorado standards, especially with regard to aluminum. It is also important to note that the recommended allowable hardness range for aluminum presented in Table 1 is slightly different from that presented in CMA's January 2010 Water Quality Control Commission (WQCC) Notice submission; to be more protective and representative of available data, CMA now proposes to cap the applicable hardness range at 220 mg/L $CaCO_3$ instead of 250 mg/L $CaCO_3$. Therefore, for hardness concentrations above 220 mg/L $CaCO_3$, the aluminum criteria calculated for 220 mg/L $CaCO_3$ apply.

Table 1: Recommended proposed updated metals standards (as µg/L) at varying hardness levels.

Recommended Equations	Mean Hardness (mg/L as $CaCO_3$)										
	25	50	75	100	150	200	220	250	300	350	400
Updated/Revised Aluminum Standards											
Acute = $e^{(1.3695\,[\ln(\text{hardness})] + 1.8308)}$	512	1,324	2,307	3,421	5,961	8,838	10,071	NA	NA	NA	NA
Chronic = $e^{(1.3695\,[\ln(\text{hardness})] + 0.9161)}$	205	530	924	1,370	2,388	3,541	4,035	NA	NA	NA	NA
Updated/Revised Zinc Standards											
Acute = $0.978*e^{(0.9094\,[\ln(\text{hardness})] + 0.9095)}$	45	85	123	160	231	301	328	368	435	500	564
Chronic = $0.986*e^{(0.9094\,[\ln(\text{hardness})] + 0.6235)}$	34	65	93	121	175	228	248	279	329	379	428

Aluminum

GEI's analysis of the current aluminum standards (GEI 2010) was initiated using the current standards document and national aluminum toxicity databases (EPA 1988), which are the basis for current Colorado surface water quality standards for dissolved Al of 750 µg/L acute and 87 µg/L chronic, as well as the footnote added at the 2005 Regulation #31 hearing (CDPHE 2009). The 1988 Aluminum Document is now over 20 years old and does not reflect current scientific understanding of aluminum toxicity to aquatic life. Note that much of the analysis summarized here and in the accompanying technical report (GEI 2010) is based on an evaluation of the EPA recalculation procedure for Arid West effluent-dependent waters conducted by GEI (then Chadwick Ecological) as part of the Arid West Water Quality Research Project, an EPA-funded program managed by Pima County Wastewater Management, Tucson AZ (AWWQRP 2006). This evaluation of the EPA recalculation procedure included an analysis of potential updates to aluminum standards.

The 1988 Aluminum Document presents acute data for 14 genera, including seven species of invertebrates and seven species of fish. These 14 species in 11 families satisfy the "eight-family rule" as specified in the 1985 Guidelines (Stephan et al. 1985). The document reports a calculated final acute value (FAV) of 1,496 µg/L with a criterion maximum concentration (CMC) = FAV÷2 or 750 µg/L (after rounding to two significant digits). Because the chronic database was limited, the acute-to-chronic ratio (ACR) approach was used to derive a chronic standard. A final ACR less than 2 was calculated, which then defaults to 2 according to EPA guidance (Stephan et al. 1985). A final ACR of 2 thus resulted in a chronic standard of 750 µg/L, or equal to the acute standard, since in both cases the FAV was divided by 2. However, EPA did not use this calculated chronic value. Additional data on aluminum toxicity for *Salvelinus fontinalis* and *Morone saxatilis* (Cleveland et al. manuscript and Buckler et al. manuscript, as cited in EPA 1988) were used by the EPA to modify the final chronic value (FCV) to protect these two species (EPA 1988). Interestingly, these two studies were deemed inappropriate for EPA's aluminum chronic database (i.e., they are included in Table 5-6, "Other Data on Effects of Aluminum on Aquatic Organisms"), but were still used to reduce the FCV from approximately 750 to 87 µg/L.

Following GEI's 2006 and 2009 reviews of the available acute studies, 35 acute data points from 13 studies were deemed suitable for addition to a revised and updated acute toxicity database. A review of the available chronic studies yielded 11 new chronic data points from nine studies, which were added to a revised chronic database. More importantly, the 2006 analysis revealed a statistically significant inverse relationship between aluminum toxicity and hardness (AWWQRP 2006). This was not reported in the 1988 Aluminum Document and represents a significant change in how aluminum toxicity should be evaluated. This pooled hardness-based slope and the final ACR were further updated from those reported in AWWQRP (2006) following the 2009 database additions and further evaluation of relevant data (GEI 2010). The resulting proposed new acute and chronic aluminum standards are presented below (Table 2). Since the aluminum equations model hardness values that ranged from 1 mg to 245 mg of $CaCO_3$/L and the slope was derived using hardness values that ranged from 26 mg to 220 mg of $CaCO_3$/L, estimations made outside of this range should be treated with caution. While convention for metals is to use up to a 400 mg/L hardness cap for calculating criteria [40CFR131.6(c)(4)(i)], a conservative approach in this case is to apply the aluminum values calculated at hardness of 220 mg/L to higher hardnesses (GEI 2010). Consistent with Colorado's current aluminum standards, the proposed standards should be applied as total recoverable aluminum. As with Colorado's other metals standards, these aluminum equations are appropriate at the allowable pH range of 6.5-9.0, and should be used at pH < 6.0 with caution (GEI 2010).

Table 2: Existing and revised acute and chronic aluminum standards (as µg total recoverable aluminum/L) at varying hardness levels.

Aluminum Equations	Mean Hardness (mg/L as $CaCO_3$)						
	25	50	75	100	150	200	220
Current EPA/Colorado Aluminum Standards							
Acute = 750							
Chronic = 87							
Updated/Revised Aluminum Standards							
Acute = $e^{(1.3695\,[\ln(\text{hardness})] + 1.8308)}$	512	1,324	2,307	3,421	5,960	8,838	10,071
Chronic = $e^{(1.3695\,[\ln(\text{hardness})] + 0.9161)}$	205	530	924	1,370	2,388	3,541	4,035

Zinc

GEI's analysis and update of the current zinc standards (GEI 2009) is based on 1) the updated Zn standards adopted by the State of Colorado in 2005 (CDPHE 2009), 2) a subsequent review as part of our evaluation of the EPA recalculation procedure (AWWQRP 2006), and 3) additional literature searches in 2008 as part of site-specific zinc standards evaluations for Colorado streams and proposals for New Mexico's Triennial Review (NMED 2010). Also, additional data from recently available studies conducted by the International Lead-Zinc Research Organization (ILZRO) were reviewed in July 2009.

As part of our literature search efforts with the current Colorado zinc equations and the additional efforts as part of the AWWQRP (2006), over 105 usable data points for 37 species were added to an updated acute database. A fall 2008 review of the available acute studies resulted in the addition of 21 more acute data points for 14 species. Additional literature reviews in 2009, which included a review of recently available studies by ILZRO, and database modifications, following further analysis of specific data points, resulted in the addition of 37 more acute data points for eight species to the revised acute zinc database, increasing the acute database from 69 to 71 genera.

In addition to the new acute data, a total of 11 data points for five species were added to the chronic database during the AWWQRP (2006) review. The fall 2008 literature review revealed three new data points for two species, one of which was already in the chronic database; thus, the updated chronic database still did not meet the "eight-family rule" for direct standards derivation of the chronic criterion. An additional literature review, which included a review of recently available studies by ILZRO, and database modifications resulted in the addition of 26 more chronic data points for three species, two of which were already in the chronic database, to the revised chronic zinc database.

The updated chronic database still does not meet the "eight-family rule". As such, the proposed chronic standards below were calculated using an updated final ACR (GEI 2009). The hardness-based slope was also updated using the new data acquired during both the fall 2008 and more recent reviews. Following these technical reviews and addition of new literature, the resulting proposed acute and chronic standards are as presented in Table 3. Consistent with Colorado's current zinc standards, the proposed standards should be applied as dissolved zinc and, as with other metals, are appropriate at the allowable pH range of 6.5-9.0, and should be used at pH < 6.0 with caution.

Table 3: Existing and revised acute and chronic zinc standards (as µg dissolved zinc/L) at varying hardness levels.

Zinc Equations	Mean Hardness (mg/L as $CaCO_3$)									
	25	50	75	100	150	200	250	300	350	400
Current Colorado Zinc Standards										
Acute = $0.978*e^{(0.8525\ [\ln(hardness)] + 1.0617)}$	44	79	112	143	203	259	313	366	417	467
Chronic = $0.986*e^{(0.8525\ [\ln(hardness)] + 0.9109)}$	38	69	97	124	176	224	271	317	362	405
Updated/Revised Zinc Standards										
Acute = $0.978*e^{(0.9094\ [\ln(hardness)] + 0.9095)}$	45	85	123	160	231	301	368	435	500	564
Chronic = $0.986*e^{(0.9094\ [\ln(hardness)] + 0.6235)}$	34	65	93	121	175	228	279	329	379	428

SUMMARY AND RECOMMENDATIONS

Given their greater ecotoxicological relevance, these updated aluminum and zinc standards are a considerable improvement over current Colorado standards. It is recommended that Colorado adopt CMA's proposed revisions for aluminum and zinc standards.

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